ENVPREDRSCHFAC
Technical Paper No. 6-72

CHANGES IN THE CHARACTERISTICS OF TYPHOONS CROSSING THE PHILIPPINES

SAMSON BRAND
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ENVIRONMENTAL PREDICTION RESEARCH FACILITY
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ABSTRACT

Thirty typhoons (1960-1970) are examined to determine the effect of the Philippines on the intensity, speed of movement and size characteristics of tropical cyclones crossing the Philippines. The results show an average intensity (maximum surface wind) decrease of 33%, a northward perturbation as the storms pass through the Islands, and a decrease of circulation size for weak typhoons. The study also showed an increase in speed of movement as storms approach the Philippines.

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LIST OF ILLUSTRATIONS

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1. INTRODUCTION

In a previous publication the forecaster was given statistical information on the geographic and seasonal variations of tropical cyclone intensity changes for 10° x 10° latitude/longitude areas of WESTPAC (Brand and Gaya, 1971). Weakening tropical cyclones at low latitudes were examined in a separate publication (Brand, 1972). It became evident from these general studies that a detailed examination of tropical cyclones crossing the Philippines would provide a useful input to the tropical cyclone forecaster, since in many situations he has to forecast the movement and intensity of storms to the west of the Philippines while they are still to the east of the Islands.

The purpose of this report is to familiarize the forecaster with those characteristics of typhoons that are affected by the Philippines and to quantitatively describe these relationships. This information, in conjunction with conventional prediction techniques, should be a useful forecast aid to the tropical cyclone forecaster.

A map of the western North Pacific Ocean area and a topographical map of the Philippine Islands are presented as Figures 1 and 2,respectively.

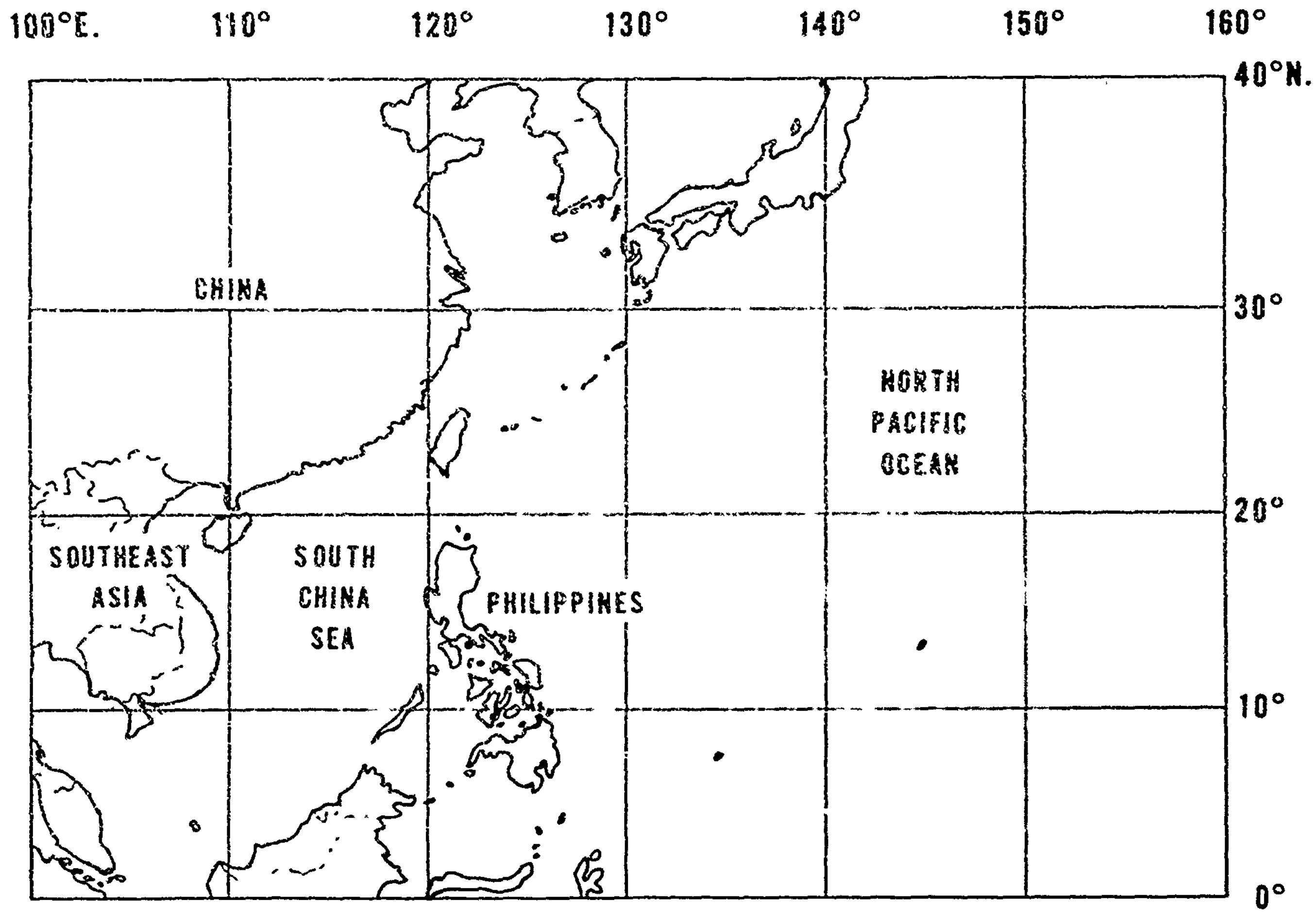

Figure 1. Map of the western North Pacific Ocean.

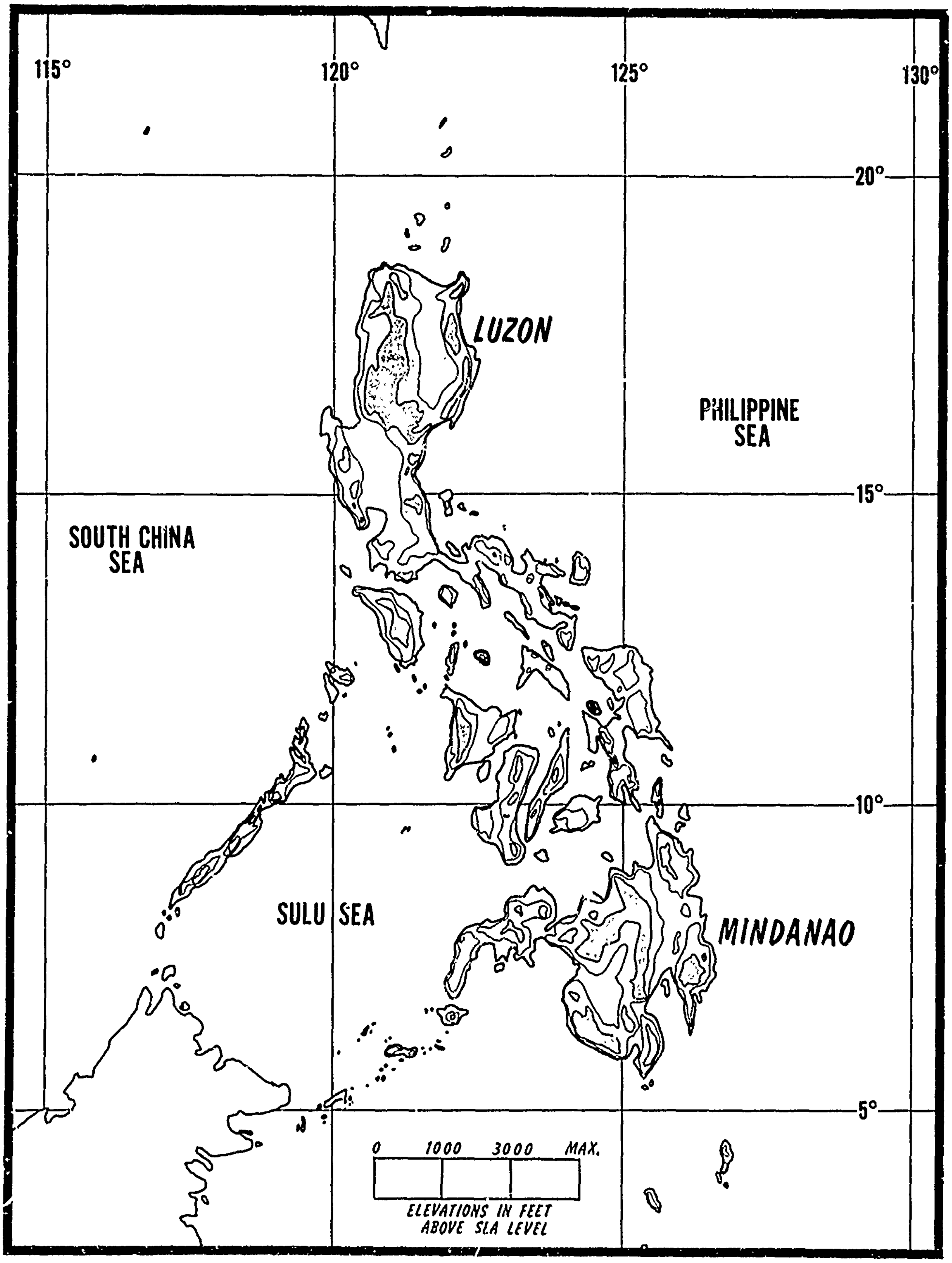

Figure 2. Topographical map of the Philippine Islands

2. DATA SOURCES

The data used for this study were extracted from the Annual Typhoon Reports published by FWC/JTWC, Guam and from a history file of tropical storms and typhoons of the western North Pacific from 1945-1969, compiled by the National Climatic Center (NCC) for and with the Navy Weather Research Facility. The history file for the period 1945-1969 contains 6-hourly information on such storm characteristics as the location, movement, size and intensity of tropical cyclonic circulations which, during their life cycle, reached tropical storm or typhoon intensity.

In this study the typhoons from 1960-1970 were examined. During this 11-year period there were 34 typhoons[1] which hit the Philippines; of this number, two recurved and two dissipated while in the Islands. The remaining 30 typhoons were studied in the time from -48 hours prior to hitting the Philippines to +24 hours after leaving the Philippines. The parameters examined in this time period were position (from fix[2] and

[1]It should be noted that in the context of this paper, a typhoon is defined as a tropical cyclonic circulation which reached typhoon intensity at some stage in its life cycle. This intensity is not necessarily achieved during that part of the circulation existence considered in this paper.

[2]The determination of the position of a tropical cyclone at a precise time, generally by reconnaissance aircraft penetration of the center or by airborne, land or ship radar or satellite photographs.

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best track[3] data), intensity (maximum surface wind), speed, size of circulation (average diameter of outer closed surface isobar) and eye diameter.

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[3]A post analysis position incorporating all available data.

3. DISCUSSION OF RESULTS

Table 1 provides a list of the 30 typhoons investigated in this study, as separated by month of crossing the Islands. Fourteen of the 30 typhoons crossed in the October-November period. The later months of the typhoon season have a great deal of tropical cyclone activity in the area of the Philippines as can be seen in Appendix A, which shows the tracks for tropical storms and typhoons for monthly and half-monthly periods (1945-1969).

The track segments for the 30 typhoons investigated in the time frame from -48 hours prior to hitting the Philippines to +24 hours after leaving the Islands (center position of storms) can be seen in Figure 3. All typhoon movement is from east to west. If the 6-hourly values of intensity and speed during this before and after period are averaged, an average intensity and speed profile for the 30 typhoons crossing the Philippines can be compiled. This is shown in Figures 4(a) and 4(b). The shaded area in the middle represents the Philippines; to the right is before crossing and to the left, after crossing.[1] The intensity profile (Figure 4(a)) shows an average increase in intensity during the period 48 to 24 hours prior to hitting the Philippines. The intensity then levels off at about 92 knots and then decreases to about 62 knots while crossing the region of the Islands (a decrease

[1] The average time the 30 typhoons existed in the Philippines was 14½ hours.

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
		SALLY 1967	VIOLET 1967		OLIVE 1960	AGNES 1963	PATSY 1962	ELAINE 1968	KIT 1960	JEAN 1962	OPAL 1964
					TRIX 1963	ELSIE 1964	CARMEN 1963	GEORGIA 1970	LOLA 1960	LUCY 1962	PAMALA 1966
					WINNIE 1964	FREDA 1965	IDA 1964		CARLA 1964	EMMA 1967	
							SHIRLEY 1968		DOT 1964	MAMIE 1968	
									CLARA 1967	NINA 1968	
									JOAN 1970	ORA 1968	
									KATE 1970	PATSY 1970	

Table 1. Typhoons crossing the Philippines in the period 1960-1970 as separated by month in which typhoons crossed the Islands.

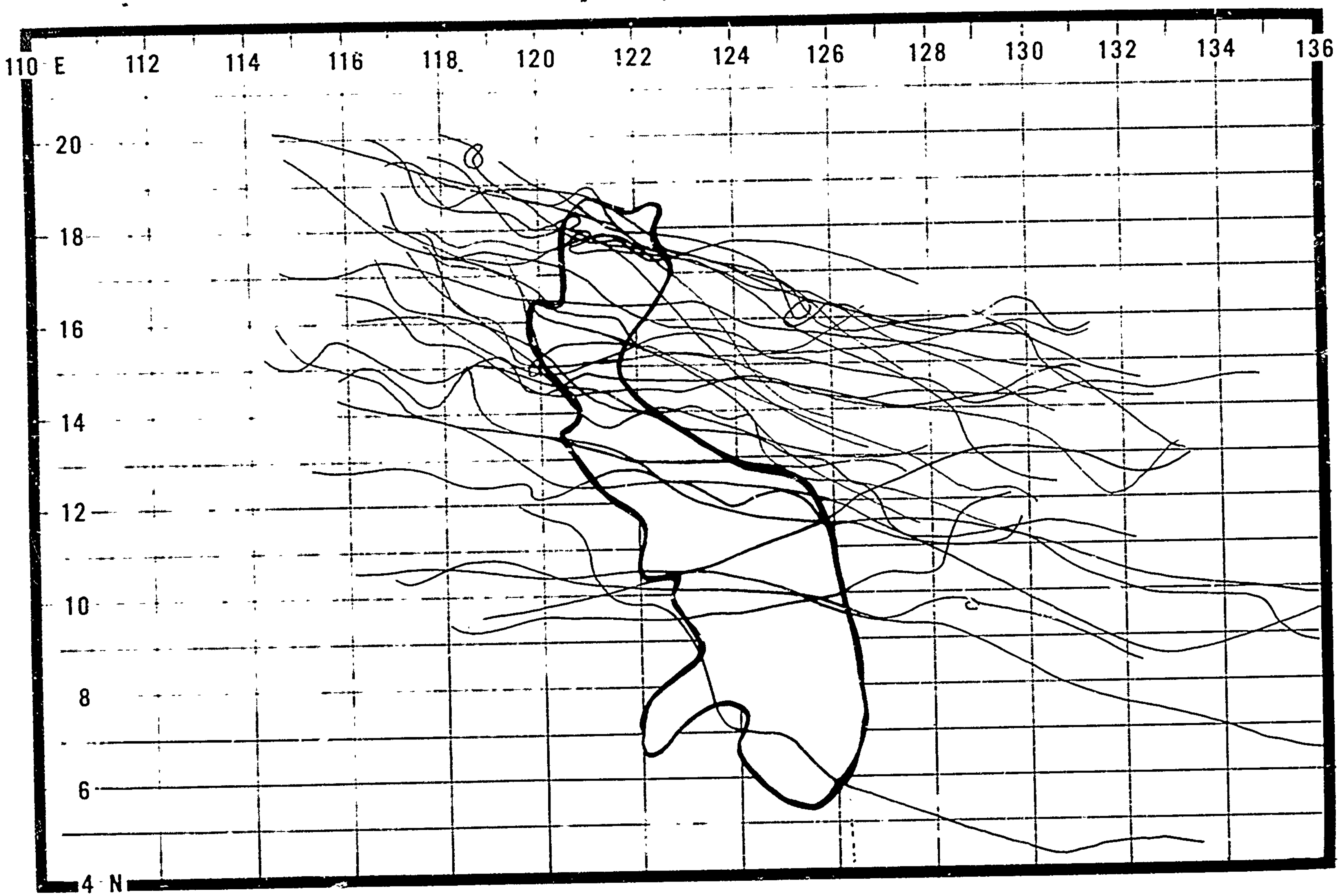

Figure 3. Track segments for 30 typhoons (1960-1970) crossing the Philippines from -48 hours prior to hitting the Philippines to +24 hours after leaving the Islands. For this study, the Philippines have been schematically represented by the above outline of the Islands. All movement is from east to west.

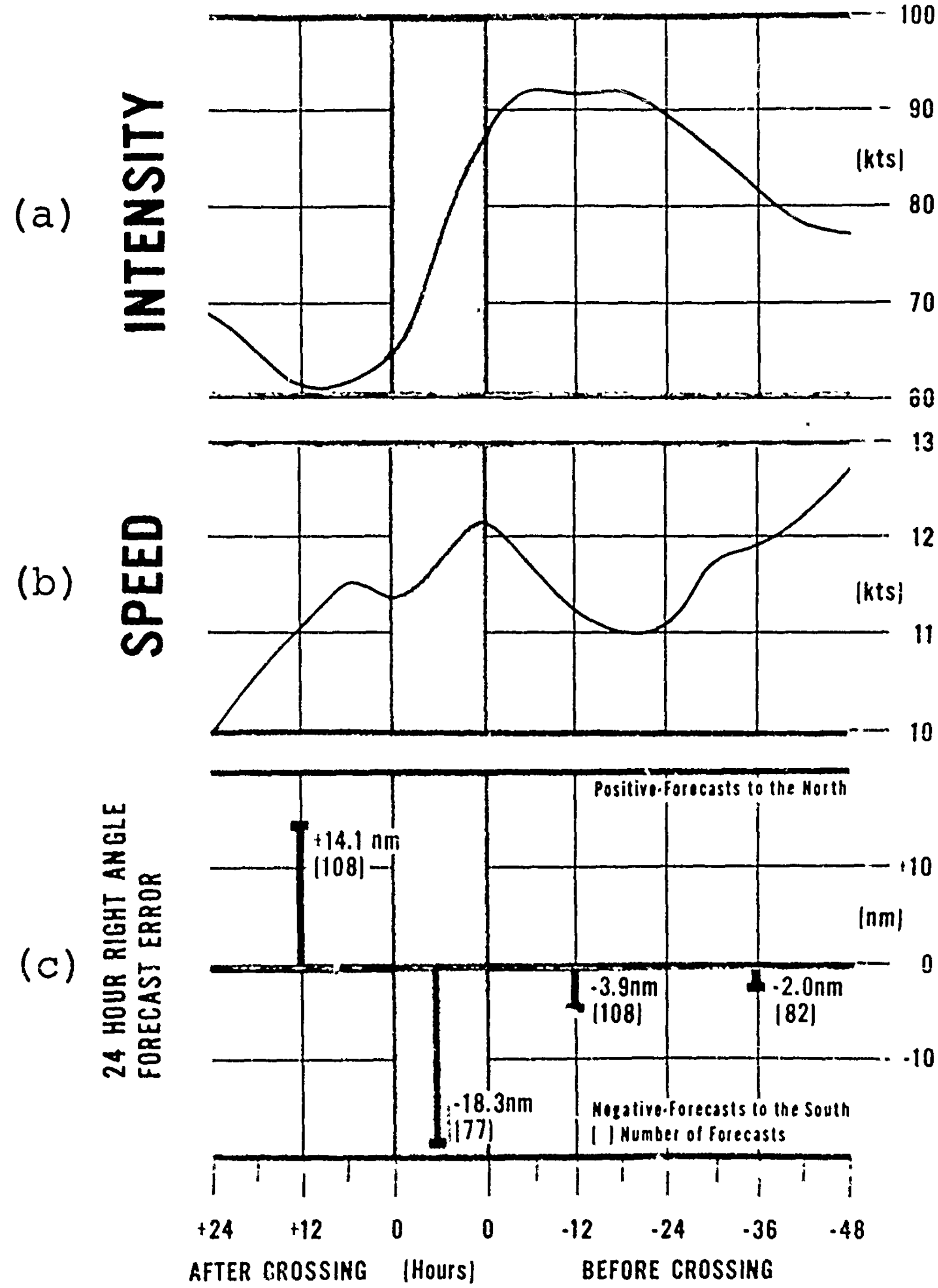

Figure 4. Average intensity (a) and speed (b) profiles for 30 typhoons crossing the Philippines from -48 hours prior to hitting the Philippines to +24 hours after leaving the Islands. The shaded area represents the Philippines. The average 24-hour right-angle forecast errors (from best track) are presented in section (c) of the figure.

of approximately 33%) before starting to increase in intensity in the South China and Sulu Seas.

The average speed of movement profile (Figure 4(b)) shows a decrease in speed until about 20 hours before hitting the Philippines, then a slight acceleration approaching the Islands (approximately a 10% increase in speed), and finally a decrease in speed again as the storms cross the Philippines and move into the South China and Sulu Seas.

Another parameter that was examined was the movement variations of storms crossing the Philippines. This was done indirectly by examining 24-hour right-angle forecast errors; that is, the forecast error to the right or left of the best track (see Figure 5). In general, a 24-hour forecast position

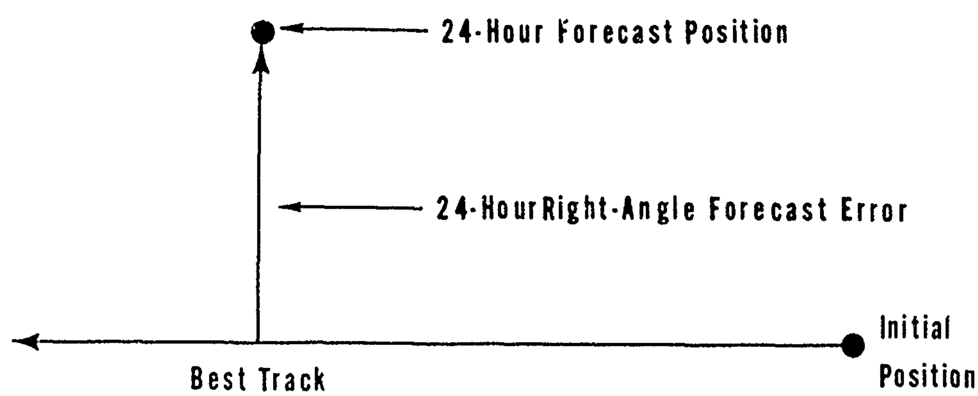

Figure 5. Schematic presentation of 24-hour right-angle forecast error

indicates where persistence and/or steering is tending to move the storm. Any deviation from this, such as an average right-angle forecast error from the best track, would point to an effect not considered in the normal forecast. For example, Figure 4(c) shows that the average right-angle forecast error for the 82 available forecasts in the 48 to 24 hours prior to hitting the Philippines is 2 n mi to the south of the best track This is reasonably near zero, which is to be expected if no bias is present. In the 24 hours prior to hitting the Islands the forecasts are again slightly to the south but near zero. It will be noted, however, that the average forecast error in the Philippines is 18.3 n mi to the south of the best track. This suggests storm movement to the north not considered by the forecaster. As storms leave the Islands the average forecast error is 14.1 n mi to the north of the best track, suggesting that either the storm centers jumped south or that the northerly movement in the Philippines was accepted by forecasters and this had an affect on the persistence element of the forecast.

The question then arises as to whether the effect of the Philippines is the same for intense and less intense typhoons. If those typhoons having an initial average intensity of $\geqslant 90$ knots in the 24-hour period prior to hitting the Philippines are separated from those typhoons having an average initial intensity of < 90 knots in the 24-hour period prior to hitting the Philippines, a dramatic difference is noted. For example,

as seen in Figure 6(a), intense typhoons are considerably affected by the Philippines, showing an average decrease in maximum wind of 45-50% while crossing the Islands. However, the weaker typhoons show a decrease in maximum wind of only 10-15% and return to their initial intensity within 24 hours of leaving the Philippines.

The speed of movement profiles (Figure 6(b)) show an acceleration towards the Islands within 18 hours of landfall for both weak and intense systems. However, the weak typhoons are generally faster moving systems and are more affected by the Islands. Note the marked decrease in speed through the Islands shown by the weak typhoons.

Another manner in which to examine the effect of the Philippines on typhoon intensity is to plot the average intensity of the storm approaching the Islands versus the change in storm intensity which occurred while traversing the Islands. This can be seen in Figure 7 which is a plot of the average 24-hour intensity prior to hitting the Philippines (I_1), versus the change in intensity ($I_1 - I_2$), where I_2 is the average 24-hour intensity after leaving the Philippines.[2] The distribution has a correlation coefficient of 0.83 and the computed regression line based on the distribution could be of use to the forecaster. For example, Figure 7 shows that if the maximum

[2] It should again be pointed out that we are examining tropical cyclones which at some stage reached typhoon intensity ($\geq$ 64 knots) but that this level of development did not necessarily fall within the period 48 hours before reaching the Philippines to 24 hours after leaving the Philippines.

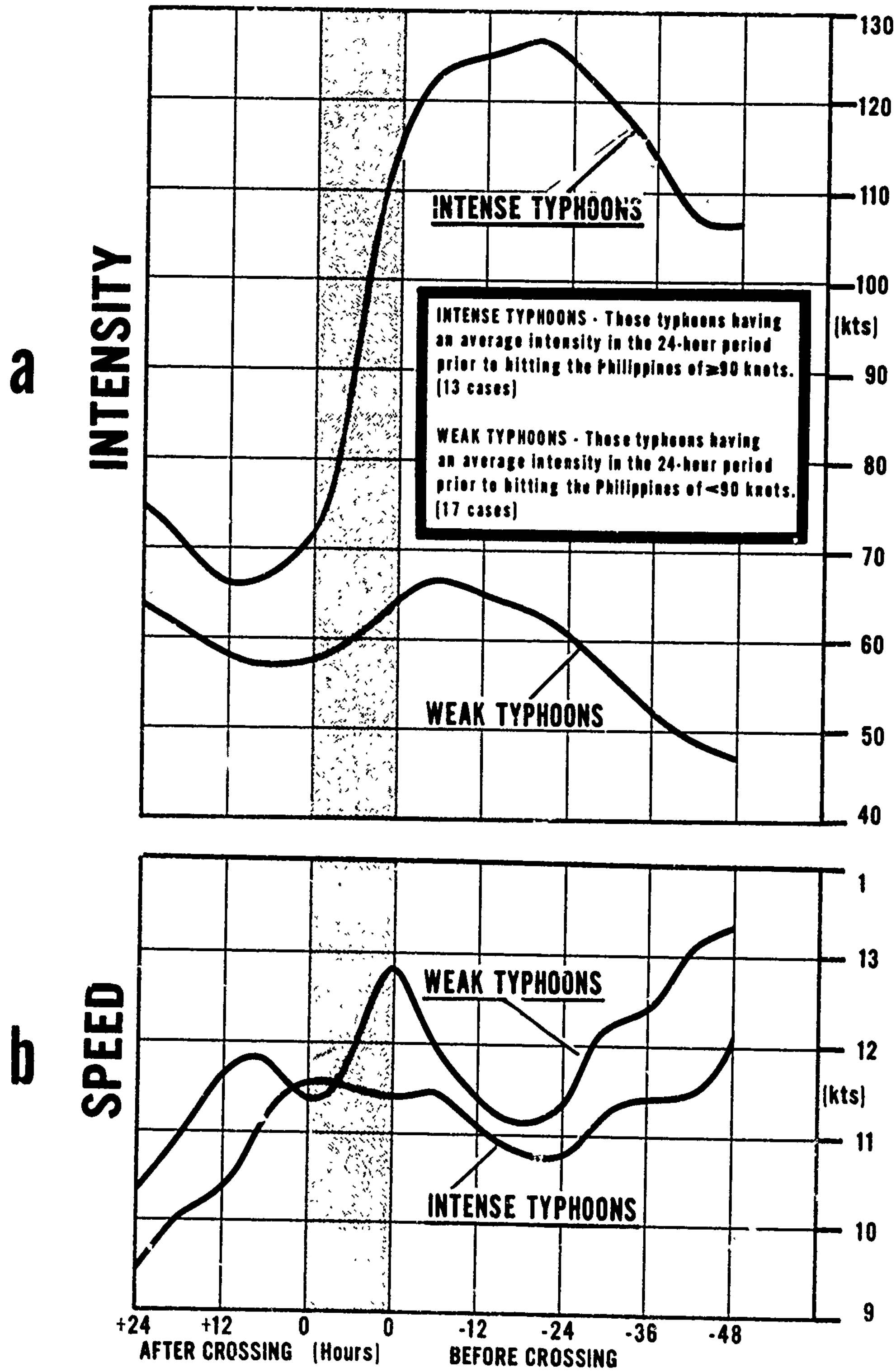

Figure 6. Average intensity(a) and speed (b) profiles for intense and weak typhoons crossing the Philippines.

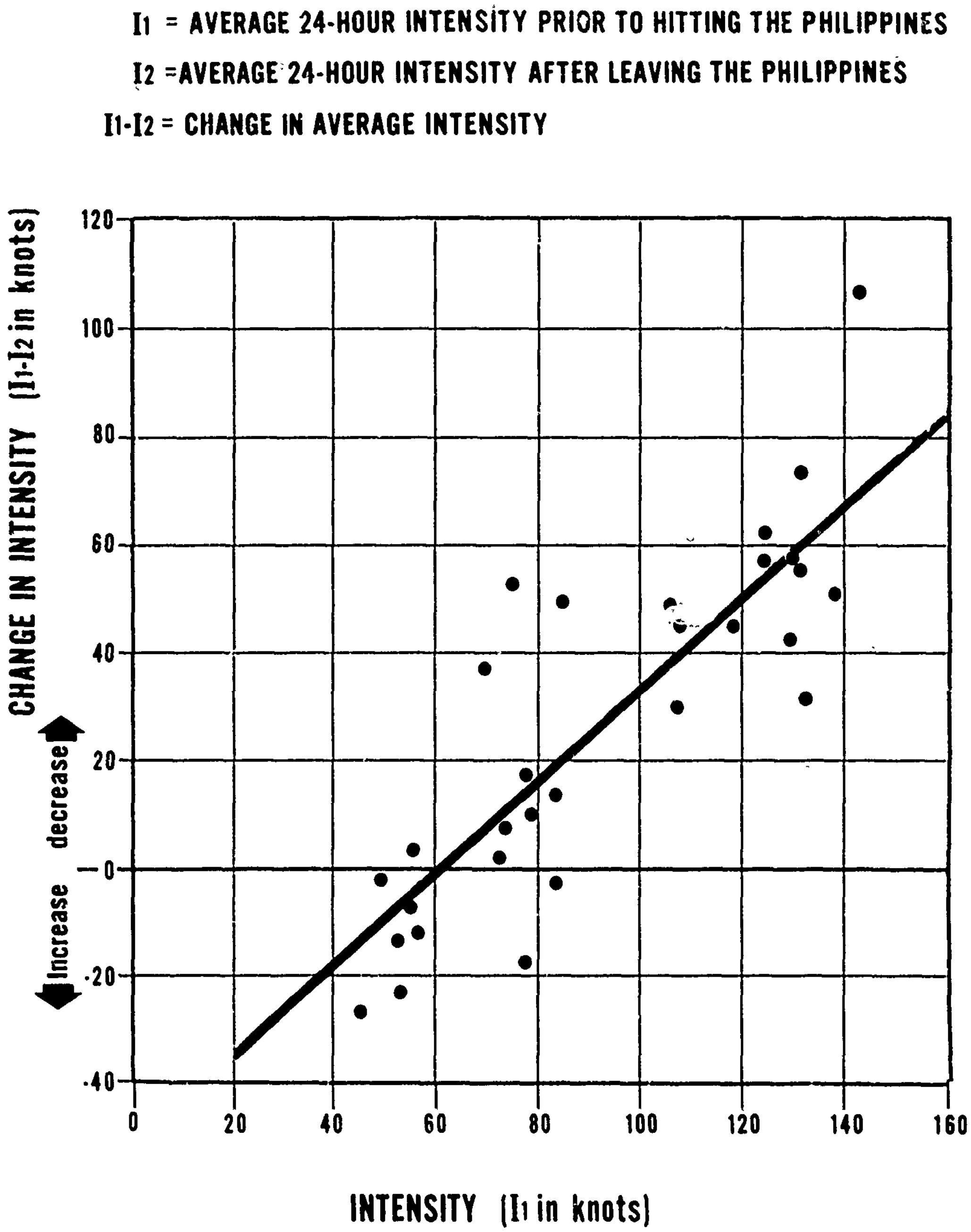

Figure 7. Average intensity of typhoons 24-hours prior to hitting the Philippines (I_1) versus the change in intensity (I_1-I_2), where I_2 is the average 24-hour intensity after leaving the Philippines.

wind in a typhoon averages 120 knots in the 24-hour period prior to hitting the Islands, then the average intensity in the 24-hour period after leaving the Islands will be 50 knots less. It will be noted that, based on the regression line, tropical cyclones with average intensities of less than 60 knots in the 24-hour period prior to hitting the Philippines exhibit an increase in average intensity in the 24-hour period after leaving the Islands. Thus, there is an indication that the intensity of tropical cyclonic circulations of less than typhoon intensity are affected very little by the Philippines.

During the course of analysis it was observed that, in general, the tracks of the more intense typhoons were further to the north than the tracks of less intense storms.

Two other parameters were examined for typhoons crossing the Philippines. These were the eye diameter of the storms and circulation size of the storms. The eye diameter data were extracted from the Annual Typhoon Reports and the size of circulation data were extracted from the history file of tropical storms and typhoons discussed earlier. The size used here is the diameter of the circulation given by the average diameter of the outer closed surface isobar.

Figure 8 shows the variations of these parameters for the 30 typhoons considered. Eye diameter data were available for 21 of the typhoons and size data for 24. From Figure 8(a) it can be seen that eye diameters increase throughout the period

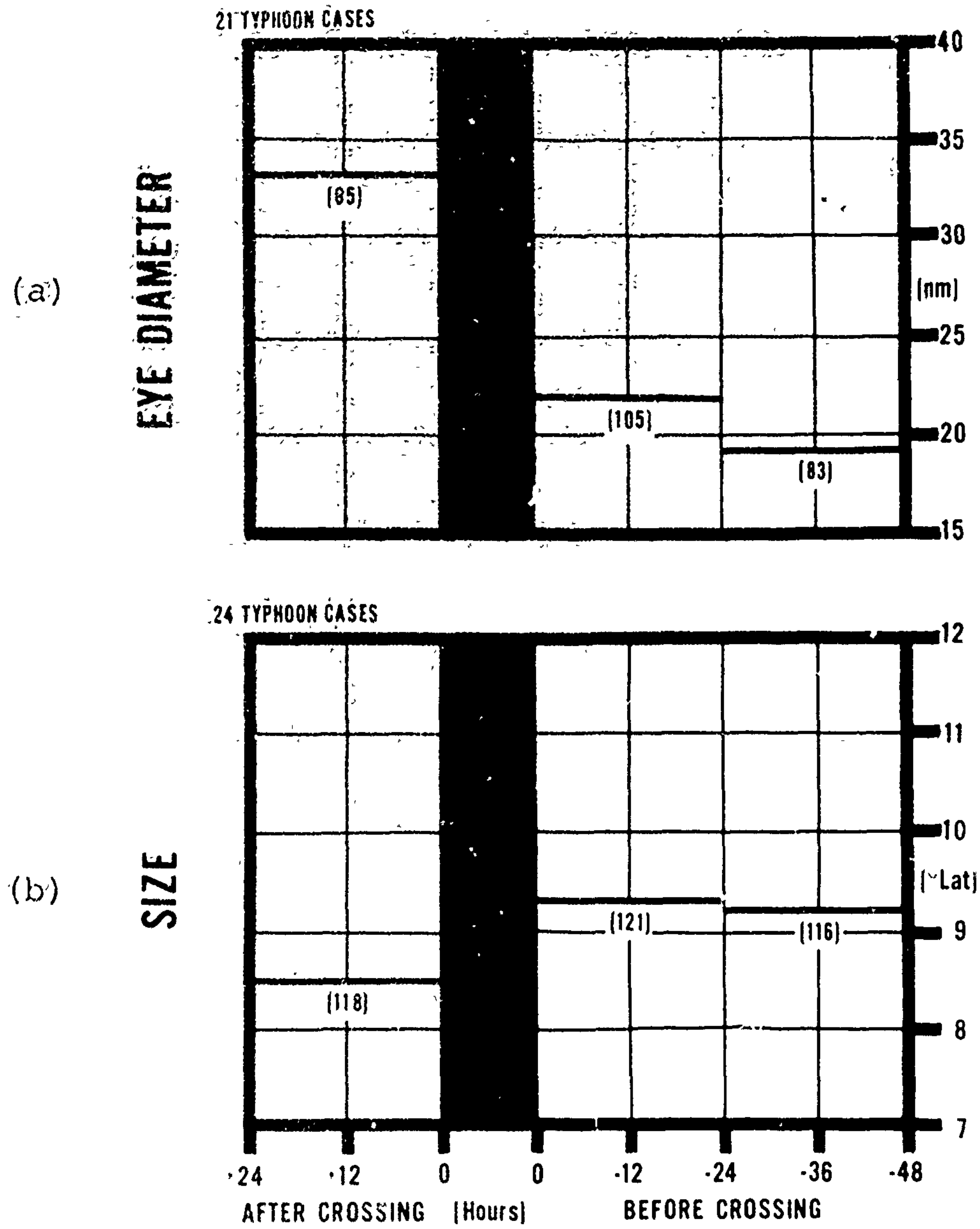

Figure 8. The eye diameter (a) and size variation (b) of typhoons crossing the Philippines. The "size" parameter is a measure of circulation size and relates to the average diameter of the outer closed surface isobar. The number of observations available is presented in parentheses.

considered.[3] However, note the large values of average eye diameter for the 24 hours after leaving the Philippines (33.2 n mi) compared with the average 24-hour eye diameter prior to hitting the Philippines (22.4 n mi). Thus, there is an indication that the Islands did have an effect on the eye diameter. The circulation size parameter shows that storms maintain their size throughout the 48-hour period prior to hitting the Islands and then decrease in size (approximately 17% in areal extent) after leaving the Islands.[4]

These parameters were further examined for intense and weak typhoons (same criteria as before) and the results can be seen in Figure 9. The eye diameter variations appear to be similar for each of the two intensity categories. Notice that the eye diameter of the intense typhoons is consistently smaller (approximately 13%) than the weaker typhoons.

The effect on circulation size varies with typhoon intensity. Intense typhoons decrease in size throughout the period considered. Weaker typhoons appear to increase in circulation size prior to hitting the Islands and then to decrease during the remainder of the period. Notice that the average circulation diameter of the intense typhoons is approximately 1-2½° latitude greater then the weaker systems.

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[3]It should be noted that the average time the 21 typhoons existed in the Philippines was 13 hours.

[4]The average time the 24 typhoons existed in the Philippines was 13½ hours.

INTENSE TYPHOONS-Those typhoons having an average intensity in the 24-hour period prior to hitting the Philippines of ≥90 knots.

WEAK TYPHOONS-Those typhoons having an average intensity in the 24-hour period prior to hitting the Philippines of <90 knots.

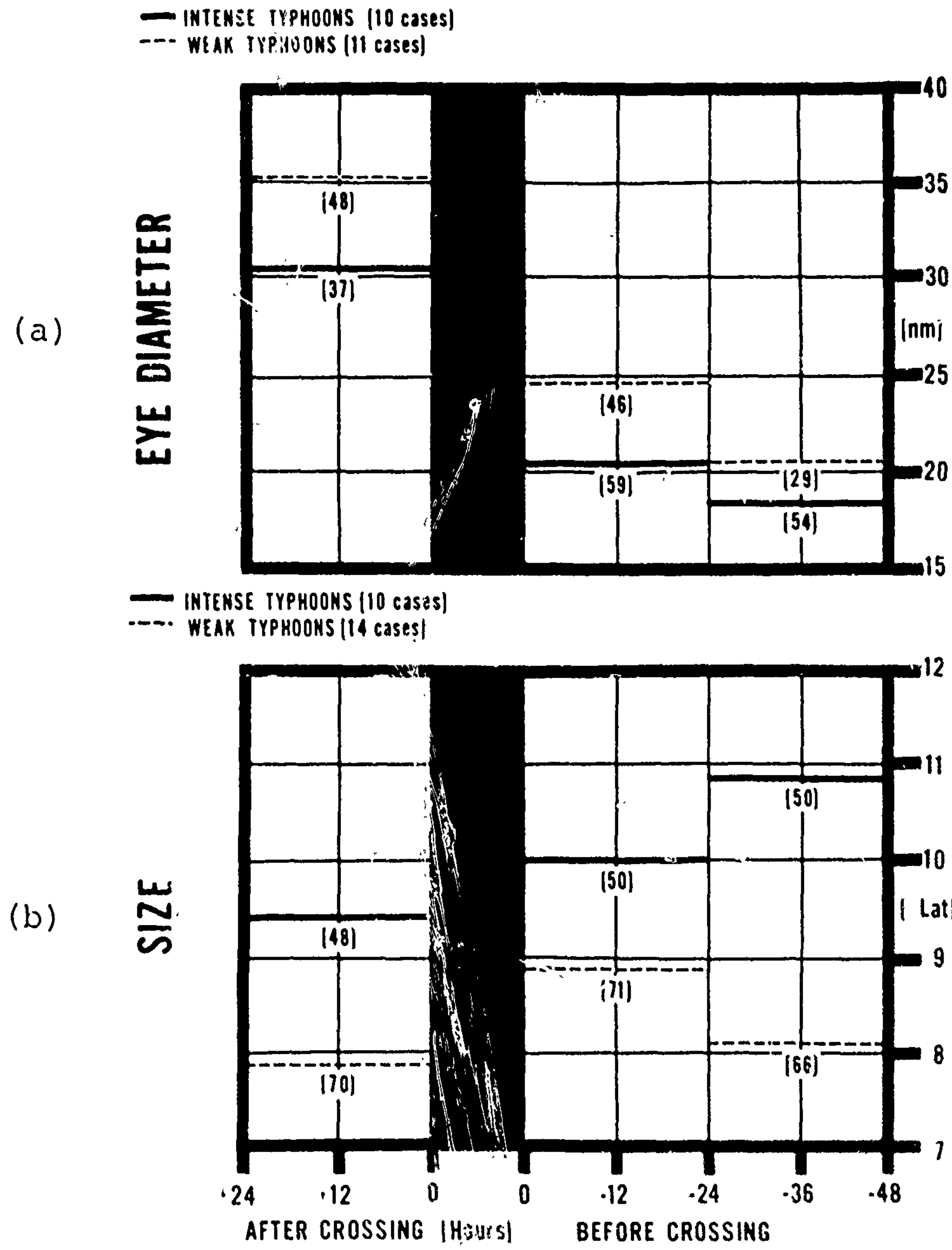

Figure 9. The eye diameter (a) and size variation (b) of intense and weak typhoons crossing the Philippines. The number of observations available is presented in parentheses.

4. SUMMARY

An attempt has been made to document the effects of the Philippines on tropical cyclones. The results presented here show that the intensity, speed, movement and size parameters of typhoons are influenced by the Philippines. Primary causes include the frictional effects of the land mass of the Philippines and the reduction in heat and moisture supplied by the ocean. However, especially in the later months of the typhoon season, the ocean environment and mean synoptic conditions of the South China Sea are different from those of the Philippine Sea, and these characteristics may well affect the behavior of storms.[1] The degree of land influence is a function of the area and topography of the terrain over which the storm is passing. The terrain of the Philippine Islands varies a great deal (see Figure 2), ranging from extensive mountainous regions on Luzon and Mindanao to a sea-island mix in the central Philippines. The forecaster should be aware of these topographical variations and keep in mind that the central region should have less effect on the storms.

The synoptics of the situation should also be taken into consideration. For example, if a tropical cyclone is crossing

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[1]Some of the effects of the summer and fall season on tropical cyclones in the South China Sea have been discussed in previous publications (Adler <u>et</u> <u>al</u>.; 1970; and Brody and Jarrell, 1969).

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the Philippines in the late typhoon season and this crossing coincides with an early surge of the northeast monsoon, cool air may enter the circulation of the storm with a resulting decrease in intensity. However, a surge may only increase the low-level cyclonic shear in the region of the South China Sea trough, if present, and this will present an excellent path for the storm.

In the later months of the typhoon season the ocean becomes a factor since the sea-surface temperature in the South China Sea decreases more rapidly than the Philippine Sea. The thermal structure parameters, other than sea-surface temperature, are also important in that they determine how much warm water is available for the energy of the storm (Brand, 1971). For example, in the later months of the typhoon season (October through December) there is less available warm water in the South China Sea than in the Philippine Sea.

It is suggested that the forecaster keep the above comments in mind and subjectively modify the forecast aids presented in this report based on the above considerations.

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APPENDIX A

TRACKS OF TROPICAL STORMS

AND TYPHOONS (1945-1969)

BY MONTHLY AND HALF-MONTHLY PERIODS

FOR THE WESTERN NORTH PACIFIC OCEAN

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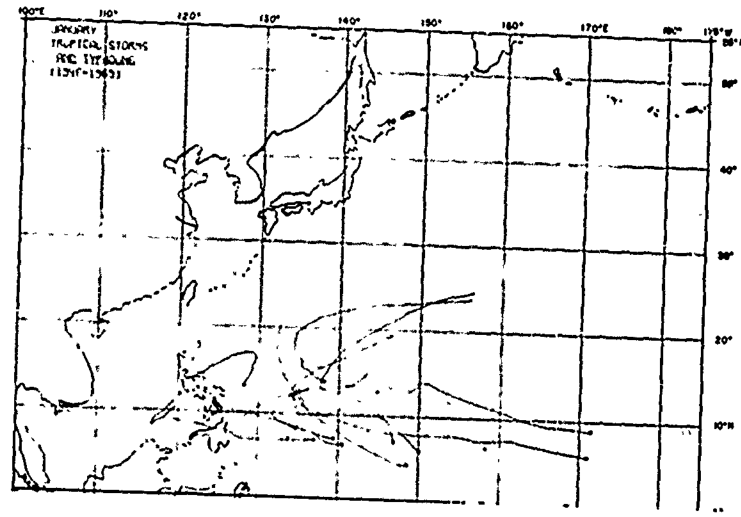
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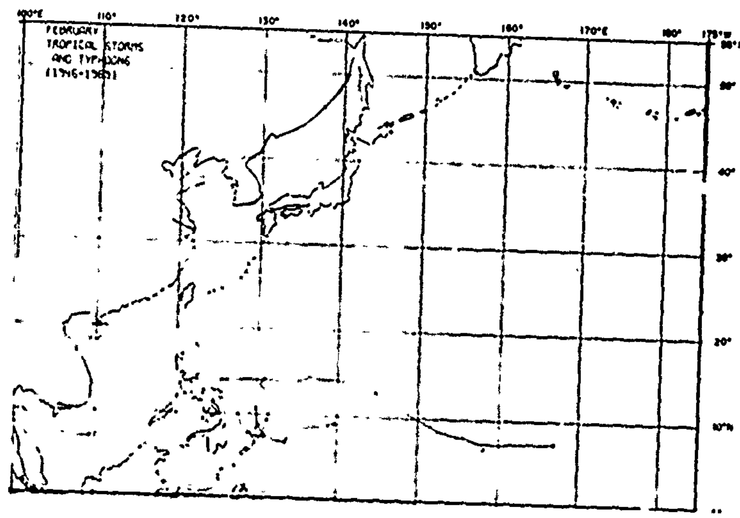
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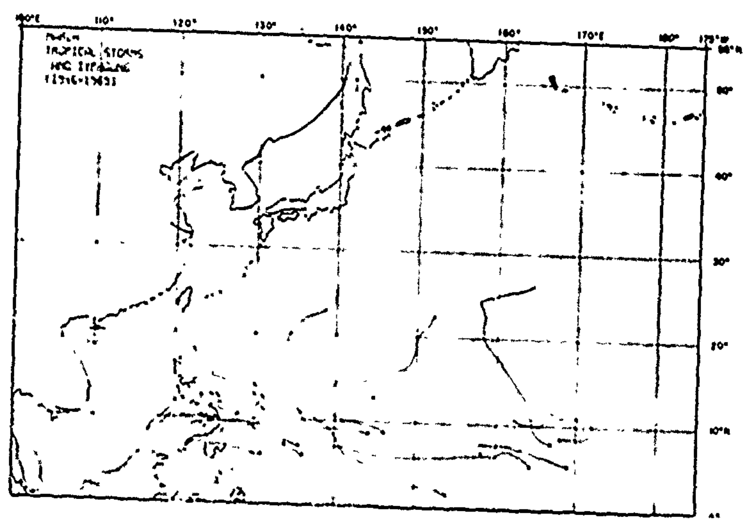
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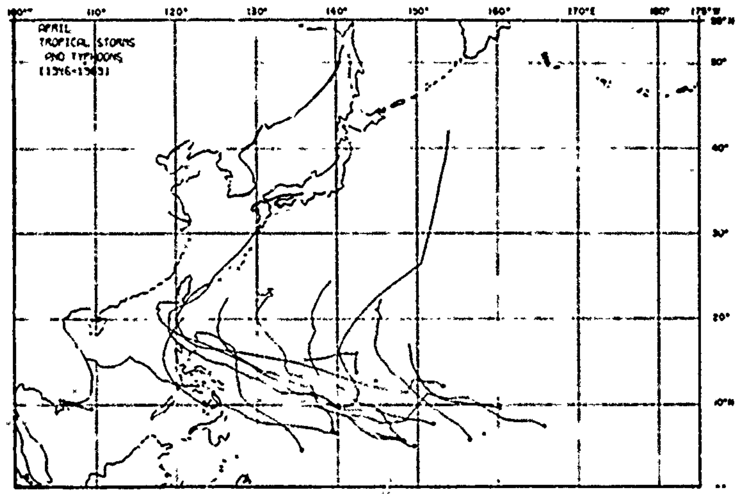
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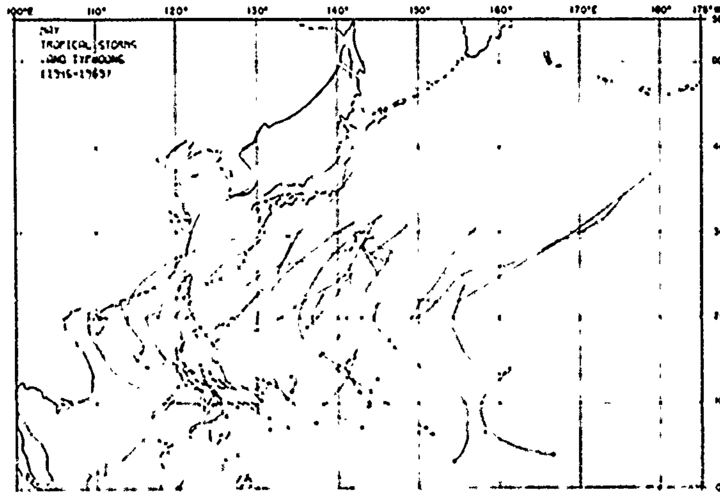
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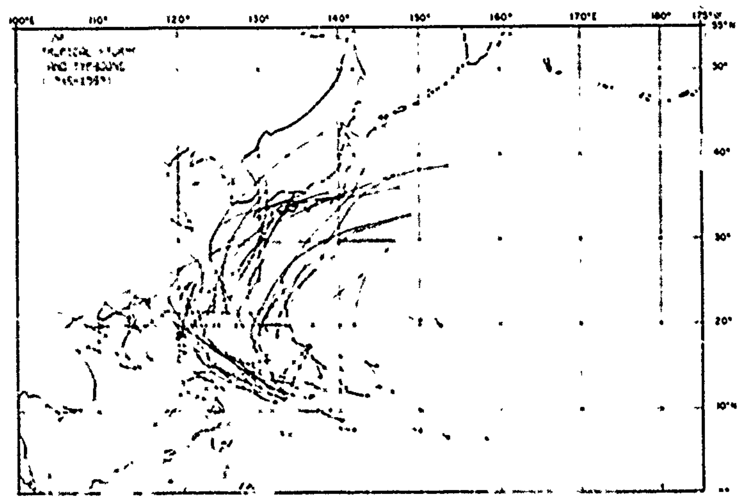
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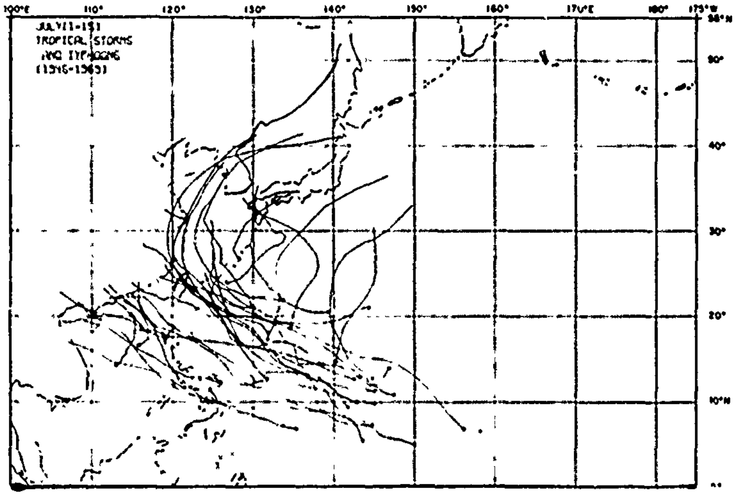

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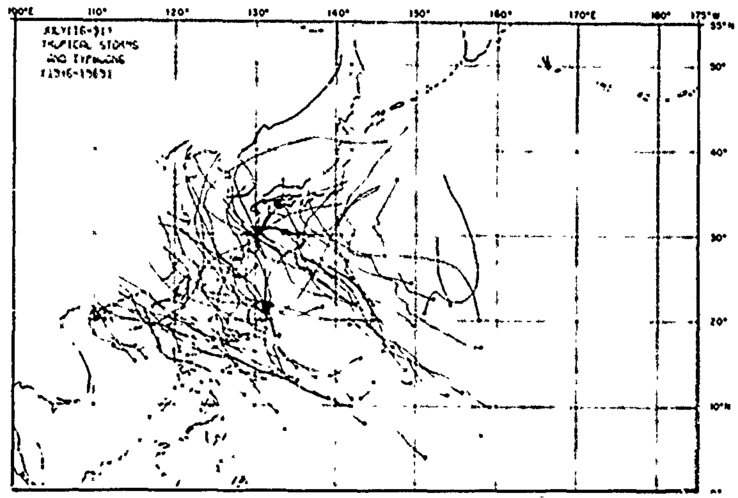

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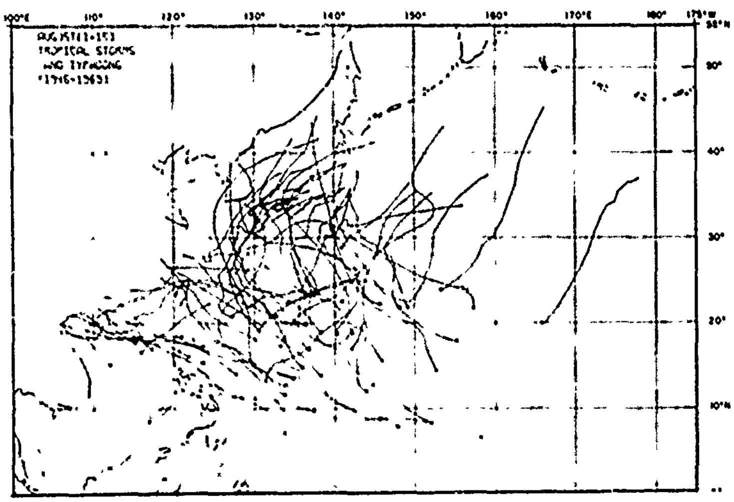

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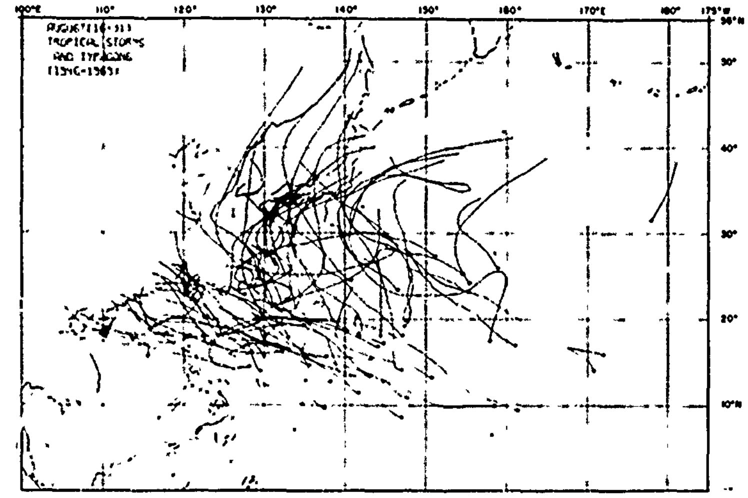

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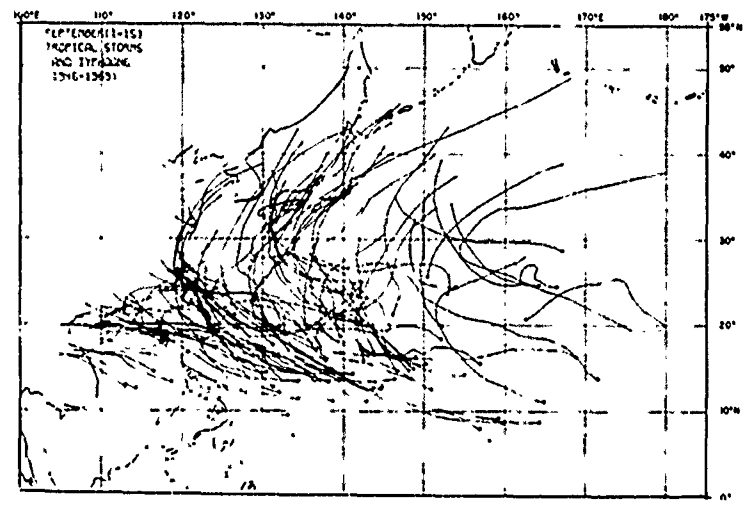

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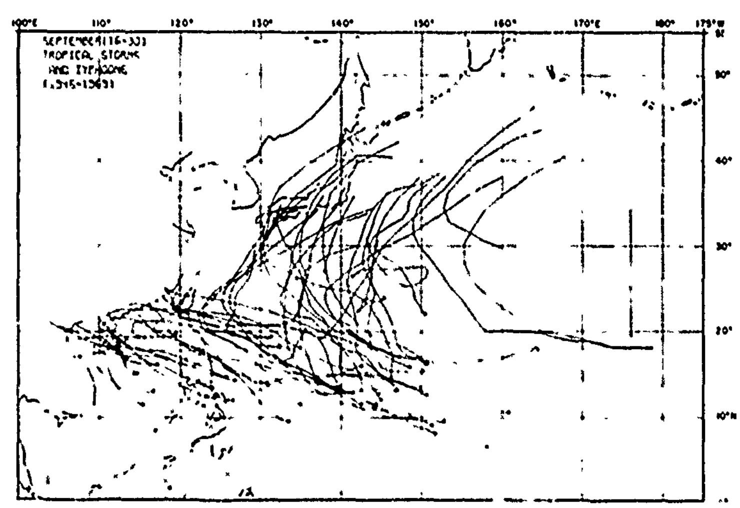

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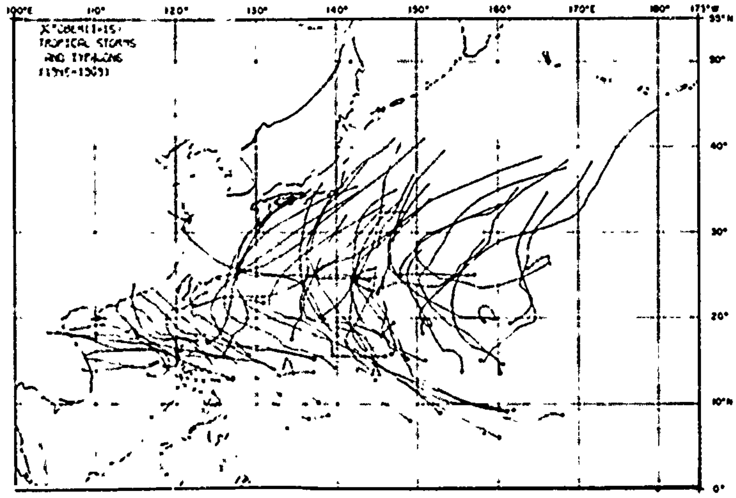

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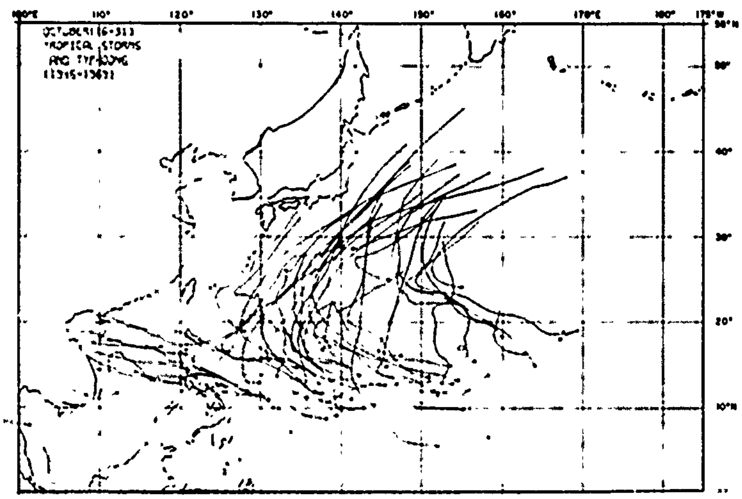

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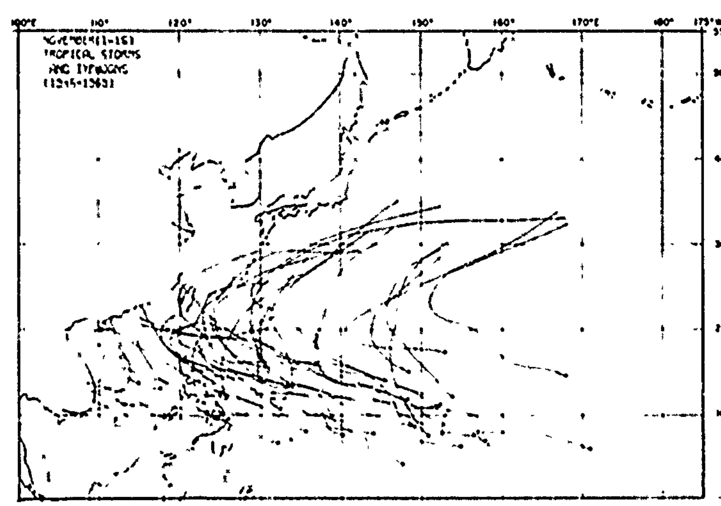

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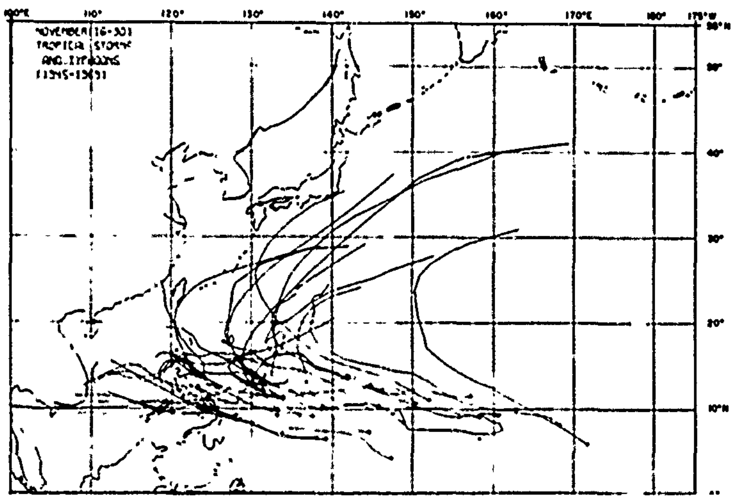
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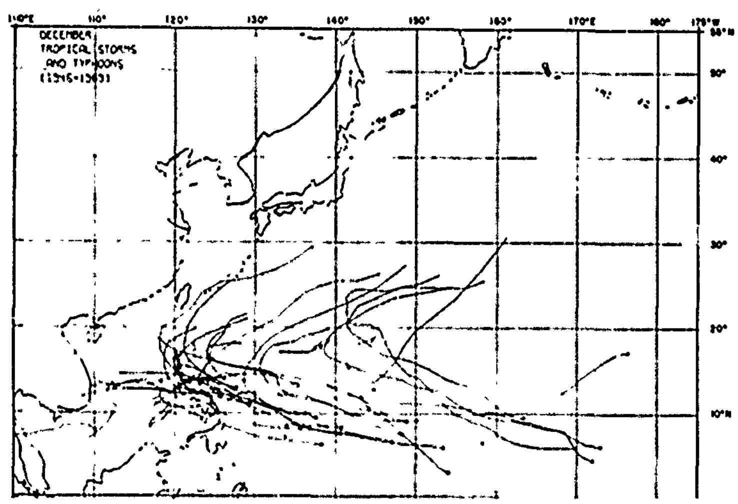
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